Potential of fast wave ICRF current drive in DEMO

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According to the present fusion roadmap, a demonstration of fusion electricity is envisaged by 2050 \cite{1}. A fusion power demonstration reactor known as DEMO should be capable of generating net electricity for the grid at the level of a few hundred Megawatts and have a closed cycle of fuel (tritium) production. Following ITER, DEMO will be the single step to a commercial fusion power plant that should economically compete with other energy sources. For the continuous operation of future tokamak-reactors like DEMO, a non-inductively driven toroidal plasma current is essential.

Currently, bootstrap current due to the pressure gradient and current driven by auxiliary heating systems are considered as the two main options to ensure the required current. The potential of the ion cyclotron resonance frequency (ICRF) heating system for current drive (CD) in DEMO-like plasmas is discussed. Fast wave CD scenarios are evaluated for both the standard mid-plane launch and for an alternative option that relies on exciting the waves from the top of the machine. Similarly to the analysis given in \cite{2,3}, optimal ICRF frequencies and parallel wave numbers are identified to maximize the CD efficiency. In the present paper, aside from full-wave numerical results, simple analytical and semi-analytical techniques are equally discussed. They allow to identify the maximum CD efficiency and to grasp its dependencies on plasma parameters. The evaluated CD efficiency for the ICRF system is shown to be at least as good as to those for the negative neutral beam injection and electron cyclotron resonance heating.

CD efficiencies of order 0.05 A/W being typical for any of the heating systems extrapolated to DEMO implies that very high auxiliary heating power needs to be installed to ensure the current needed for continuous operation. Another possibility is also discussed: the quasi-continuous tokamak operation based on varying the toroidal direction of the plasma current \cite{4}. It could be a possible alternative solution for enabling a steady-state energy output tokamak-reactor.

References

\begin{enumerate}
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